3.20 PALEONTOLOGY

3.20.1 Affected Environment

The assessment area is located in the northwest corner of the Great Basin portion of the Basin and Range physiographic province of the western United States. The north trending mountain ranges and intervening valleys are, in part, composed of rock and sediments (consolidated and unconsolidated) that contain fossils of plants and animals.

No systemic field survey has been conducted for paleontological resources in the WFO or the assessment area. In 1978, BLM contracted paleontologist David Lawler (Lawler, 1978; Lawler and Roney, 1978) to review literature, summarize previously known paleontological resources, and analyze the potential for unknown resources in the WFO. Since then, independent researches have identified numerous paleontological localities within the WFO boundaries. Some localities are located in and near the assessment area. Many of the sedimentary units that lie within the assessment area are potential localities for occurrences of fossils.

The assessment area also includes several sources of paleoenvironmental information. These include fossil pollen localities, ancient woodrat middens, and quarternary sedimentary shoreline features/deposits related to Lake Lahontan history. Areas that have been continuously wet through time (e.g., springs and meadows) or, conversely, areas that have been continuously dry (e.g., dry caves or woodrat middens) are most likely to preserve fossil pollen record. Woodrat middens are found in dry caves and on cliff faces. Volcanic ashes are also important stratigraphic and chronological markers. Trego Hot Springs area contains an important ash layer. Streams also have the potential to yield valuable information on changing stream flow and erosion through time. Information on fluctuations of Pleistocene Lake Lahontan is provided in wave-cut terraces, gravel bars, beaches, and tufa deposits.

Note: The discussions are taken from Lawler, 1978; Lawler and Roney, 1978; Jefferson et al., (no date); and Firby, 1983 unless otherwise referenced.

Northwest Region. The geologic units in this region likely to contain fossils are volcaniclastic and tuffaceous sediments of Virgin Valley Formation of Miocene age and the tuffaceous sediments, sands, and ashes of the Thousand Creek Formation of Pliocene age. Both of these formations have yielded fossils outside of the assessment area. These formations do occur within the PVA 1 so there is a high likelihood that fossils may occur there. One of the recorded sites occurs within PVA 1 north of McGee Mountain. The others are located west and north outside PVA 1. The Virgin Valley Formation has yielded rich mammalian fauna, turtles, mountain beavers, camel, mastodon, large cats, dogs, raccoon, hare, horse, rhino, pig, deer, pronghorn, large conifer trees, rushes, and willows. The Thousand Creek Formation has yielded the most complete mammalian fauna in Nevada. The deposit has yielded remains of various species of snake, goose, moles, bear, mastodon, rhino, camel, large cats, dog, squirrel, beaver, pocket gopher, rats, mice, voles, hare, kangaroo rat, pocket mice, pig, and pronghorn.

Black Rock Desert Region. This region contains a variety of geologic units that are known to contain fossils. A small outcrop of Permian age limestone at the south end of the Bilk Creek Mountains includes a richly fossiliferous zone with corals, bryozoa, fusulinids, echinoids, brachiopods, and gastropods. This outcrop is located east of PVA 2. These similar rocks occur within PVA 2 at the north end of the Jackson Mountains and on the east side of the Pine Forest Range. In fact, corals, mollusks, and crinoids of Triassic age have been identified from the eastern slopes of the Pine Forest Range, within PVA 2. The recovery of marine Triassic and Jurassic fossils is anticipated in the Krum Hills, Blue Mountain, and Eugene Mountains. These are all located close to PVA 7. Gastropods, pelecypods, ostracods, and algal stromatolites occur in the King Lear Formation in the Jackson Mountains. PVA 4 is located immediately east of the area. Miocene diatomaceous deposits that include a number of diatom species have been found in the Jackson Range. Petrified wood has been found in the southeastern Pine Forest Range within or very close to PVA 2. Unidentified Miocene age fossils have been reported in the McDermitt area in PVA 5. Pliocene age fossil vertebrates and plants have been reported in abundance from the Rabbithole area. This site is located outside the assessment area; however, PVA 8 and PVA 4 may have similar rocks. A late Tertiary deposit in the Spring Creek in PVA 6 area contains freshwater fish and plant remains (willow, oak, and elm). A five-foot thick layer of strata composed entirely of fresh water gastropods has been reported from the Black Rock Desert east of PVA 4. Several sites yielding Pleistocene mammoths and associated fauna have been recorded in the east arm of the Black Rock Desert near PVAs 2 and 4. Lease applications NVN07300 and NVN07301 located at Pinto Hot Springs are close to one of these sites. Associated fossils include wolf, horse, camel, sabor tooth, ducks, geese, rabbit, mice, rats, deer, and bison. A rock shelter located seven miles south of PVA 4 has yielded Holocene age lizard, ground squirrel, coyote, and bighorn sheep. A late Holocene site at Trego Hot Springs near PVA 8 has yielded a large assemblage of vertebrate fossils including lizards, birds, ground squirrel, lynx, coyote, bison, bighorn sheep, rabbit, rats, and snakes.

Humboldt River Region. Geologic units present in this region range in age from early Paleozoic to Late Quaternary (Recent) in age. The likelihood of discovering fossils in many of the formations known to contain fossils is high. The Cambrian Preble Formation in the Osgood Mountains, in PVA 7, contains brachiopods, snails, tentaculities, and trilobites. The Cambrian Harmony Formation in the Osgood Mountains and Hot Springs Range contains trilobites in close proximity to PVAs 6 and 7. The Ordovician Comus and Valmy Formations in the Osgood Mountains and in the Antler Peak areas have yielded graptolites and trilobites in PVA 7. Late Paleozoic Goughs Canyon Formation in the Osgood Mountains near PVA 6 has yielded a varied assemblage of corals, bryozoans, and brachiopods. Conodonts, fusulinids, bryozoans, corals, and brachiopods have been recovered from the Pennsylvanian to Permian Battle, Highway, Antler, Pumpernickel, and Havallah Formations in the Osgood Mountains and near Antler Peak in PVA 7. In Pumpernickel Valley lease applications NVN074855 and NVN060215 are located in close proximity to Pumpernickel and Havallah rocks. Lease applications NVN074276 and NVN074299 occur in PVA 11 near outcrops of the Pumpernickle and Havallah Formations, so there is a high likelihood the fossils exist there also. The Triassic Prida, Natchez Pass, Grass Valley, and Dun Glenn Formations have yielded a wealth of fossils such as icthyosaurs, sharks, ammonites, pelecypods, brachiopods, and hermatypic corals throughout the Humboldt Range. These formations occur on the west side of the Humboldt Range in PVA 9, where these fossils could also occur. Horse, cat, rabbit, rhino, camel, gomphothere (mastodon), and unidentified

plant remains have been recovered from Miocene tuffaceous sediments in the Coal Canyon area in PVA 9. Lease applications NVN074902 and NVN075419 are located in this area. A petrified wood fossil of Tertiary age was found in the Trinity Range east of Toulon. An early Pliocene floral assemblage, consisting of 23 species, representing 6 conifers, 1 monocotyledon, and 16 dicotyledons, has been identified near Desert Peak at the southern end of the Humboldt River Region, but also near the West Central, and Truckee River Regions (portions of PVA 8 overlay these three regions). Oak, juniper, pine, cottonwood, poplar, and cedar are present in this assemblage. The same sedimentary rock units may be present in scattered locations in PVA 8 that lies within the West Central Region. In PVA 8, part of the Brady KGRA and lease applications NVN074871, NVN074872, NVN074873 are located in close proximity to the fossil assemblage. This sedimentary unit also occurs in scattered locations throughout the southern end of PVA 8, in the West Central and Truckee River Regions. A significant locality in PVA 9, near Rye Patch dam and Rye Patch KGRA, has yielded late Pleistocene elephant, horse, camel, and rodents. Other mammoth localities have been noted in this region. A fossil elephant was recorded at the west end of PVA 7, near Rose Creek. Lease application NVN074903 is located close to this site. A camel was identified within PVA 7 and a Holocene coyote was recovered in the Mazama ash, both near Winnemucca.

West Central Region. Miocene and Pliocene age volcanic and tuffaceous sedimentary rocks have yielded a wide variety of fossil plants and animals in this region especially within and near PVA 8. A rhino tooth of Miocene age has been reported in the Hot Springs Mountains. As stated above, an early Pliocene floral assemblage, consisting of 23 species, representing 6 conifers, 1 monocotyledon, and 16 dicotyledons, has been identified from the Chlorophagus Formation near Desert Peak in the Hot Springs Mountains at the southern end of the Humboldt River Region near the West Central Region. Oak, juniper, pine, cottonwood, poplar, and cedar are present in this assemblage. A large mammalian assemblage of Pliocene age commonly referred to as the "Brady Pocket" has been studied along the Nightingale Road north of the Brady KGRA in PVA 8. The following fauna identified in the Brady Pocket includes rodent, beaver, dog, cat, tapir, gomphothere (elephant family), rabbit, and camel. Localities adjacent to the Brady Pocket have also yielded fish and bird fossils. The remains are derived from tuffs, sands, shales, and pebble conglomerates of the Truckee Formation. A scatter of Pliocene vertebrate containing camel, horse, and a bird has been recorded near Sage Hen Creek in PVA 8. A Pliocene floral assemblage near Hazen, about 10 miles south of Brady KGRA in the Carson Desert Region, contains fossil walnut, shrub, avocado, oak, and sumac. An outcrop of petrified wood was noted in the Wildcat Canyon area of the Seven Troughs Range in PVA 8. Late Miocene fossils were recorded from diatomaceous sediments within PVA 8 in the vicinity of Eagle-Picher Mine including a few small leaves and fish.

Truckee River Region. Geologic units in this region with the potential of containing fossils are the Mesozoic sediments in the Nightingale Mountains and the Miocene and Pliocene volcanic sedimentary and tuffaceous units in the Truckee Range. An unnamed fossil of Jurassic age has been recovered from the Nightingale sequence at the north end of the Nightingale Range in PVA 8. As stated above, an early Pliocene floral assemblage, consisting of 23 species, representing 6 conifers, 1 monocotyledon, and 16 dicotyledons has been identified near Desert Peak, at the southern end of the Humboldt River Region near the Truckee River Region. Oak, juniper, pine, cottonwood, poplar, and cedar are present in this assemblage. The same

sedimentary rock units appear to be present in scattered locations in PVA 8 that lies within the Truckee River Region. Lease applications NVN074913 and NVN074914, in the central Truckee Range, may be located in an area where related sedimentary units may occur. Several sites in the Winnemucca Lake area in or near PVA 8 have yielded fossils. Pleistocene fossil mountain lion, camel, horse, bighorn sheep, and cormorant were identified at Crypt Cave in the vicinity of Winnemucca Lake. Falcon Hill at the north end of Winnemucca Lake yielded a mandible of a Shrubox, a late Pleistocene animal. The remains of a cheetah have also been noted at this site. Fishbone Cave on Winnemucca Lake has yielded a vertebrate assemblage of Holocene age consisting of fish, lizards, ducks, coot, merganser camel, horse, and marmots. Several Holocene and Pleistocene fossil sites have been identified at Pyramid Lake. The assemblages include camel, horse, mammoth, bison, fish amphibians, reptiles, chipmunks, dogs, bighorn sheep, sloth, and jackrabbit. These locations are close to and similar to PVA 8 in the vicinity of Winnemucca Lake.

Carson Desert Region. Several Pliocene assemblages have been identified near Hazen, about 10 miles south of Brady KGRA. A flora assemblage contains fossil walnut, shrub, avocado, oak, and sumac. A vertebrate fauna assemblage has yielded ray-finned fish, bird, rodent, carnivore, and horse material. A locality southwest of Hazen has yielded fossil blue racer snake, stickleback fish, and camel from the Truckee Formation. These formations may also be present in PVA 8 and near the Brady KGRA.

Central Region. Conodonts and fusulinids have been recovered from Paleozoic Pumpernickel and Havallah Formations in PVA 7. There is a potential for the fossils to occur in PVA 13 because these formations are also present there. This region contains many fossiliferous rock units of Triassic age. Many of the Triassic fossiliferous sediments that occur in the Humboldt Range in PVA 9, also occur in the Tobin Range and the Augusta Mountains in PVA 13. Ammonites have been identified in the Triassic Prida Formation in the Tobin Mountain Range (in PVA 13). A newly discovered Triassic age reptile Augustasauras has been recovered from the Augusta Mountains along the east side of PVA 13 (Sander, et al 1997). The fossil was collected from the Favret Formation. A Ceolocanth has also been identified at the location. Fossil horse, camel, fish, rhino, beaver, and dogs of Miocene age have been recovered from tuffaceous sediments in Jersey Valley in PVA 13. Lease application NVN074883 is located here. Pleistocene bighorn sheep, and bison remains have been reported from Willow Creek area in the East Range. PVA 10 is located approximately six miles south of these locations. Similar fossils may exist there also. Lease applications NVN74276 and NVN74299 are present there at Kyle Hot Springs. Dixie Valley KGRA is the site of a Late Pleistocene mammoth and a fossil elephant has been identified from Sou Hot springs in PVA 13.

3.20.2 Environmental Impacts

3.20.2.1 Proposed Action

Direct Impacts – There are no direct impacts to issuing leases for future geothermal exploration, development, and production activities.

Indirect Impacts – The indirect impacts are represented in the "reasonably foreseeable development scenario" outlined below:

Exploration. Impacts to paleontological and paleoenvironmental resources during the exploration phase could vary from minimal to severe. Cross-country vibrosis seizmic work could impact surface sites. Drilling temperature gradient wells, associated well pad preparation, and access road construction could impact both surface and subsurface sites. If dessication of permanently wet areas, such as where springs or meadows occur, fossil pollen records could be destroyed. Increased accessibility could result in impacts to paleontological sites from hobbyist collecting and unauthorized commercial collecting.

Development. Surface disturbance during the development phase would be more extensive than the exploration phase, increasing the potential impacts to paleontological sites. Impacts to surface and subsurface paleontological and paleoenvironmental resources could occur from road construction, drill site development, geothermal pipelines, and power plant and transmission line construction. If dessication of permanently wet areas, such as springs or meadows, occurs, fossil pollen records could be destroyed. As in the exploration phase, roads, pipelines, and transmission lines could increase un-permitted collecting.

Production. Most, if not all impacts to paleontological resources would have occurred prior to the production phase. Very few changes affecting palenotological or paleoenvironmental resources would occur during this scenario phase.

Close-out. Previously undisturbed paleontological or paleoenvironmental resources could be impacted if any new surface disturbance occurs during rehabilitation activities.

3.20.2.2 No Action Alternative

Direct Impacts – There would be no direct impacts to paleontological or paleoenvironmental resources.

Indirect Impacts – Indirect impacts from the No Action Alternative would be similar to those described in the Proposed Action; however, updated mitigation measures and stipulations would not apply using the 1982 Geothermal EA.